CineGrid™
Networks for Digital Cinema and Beyond

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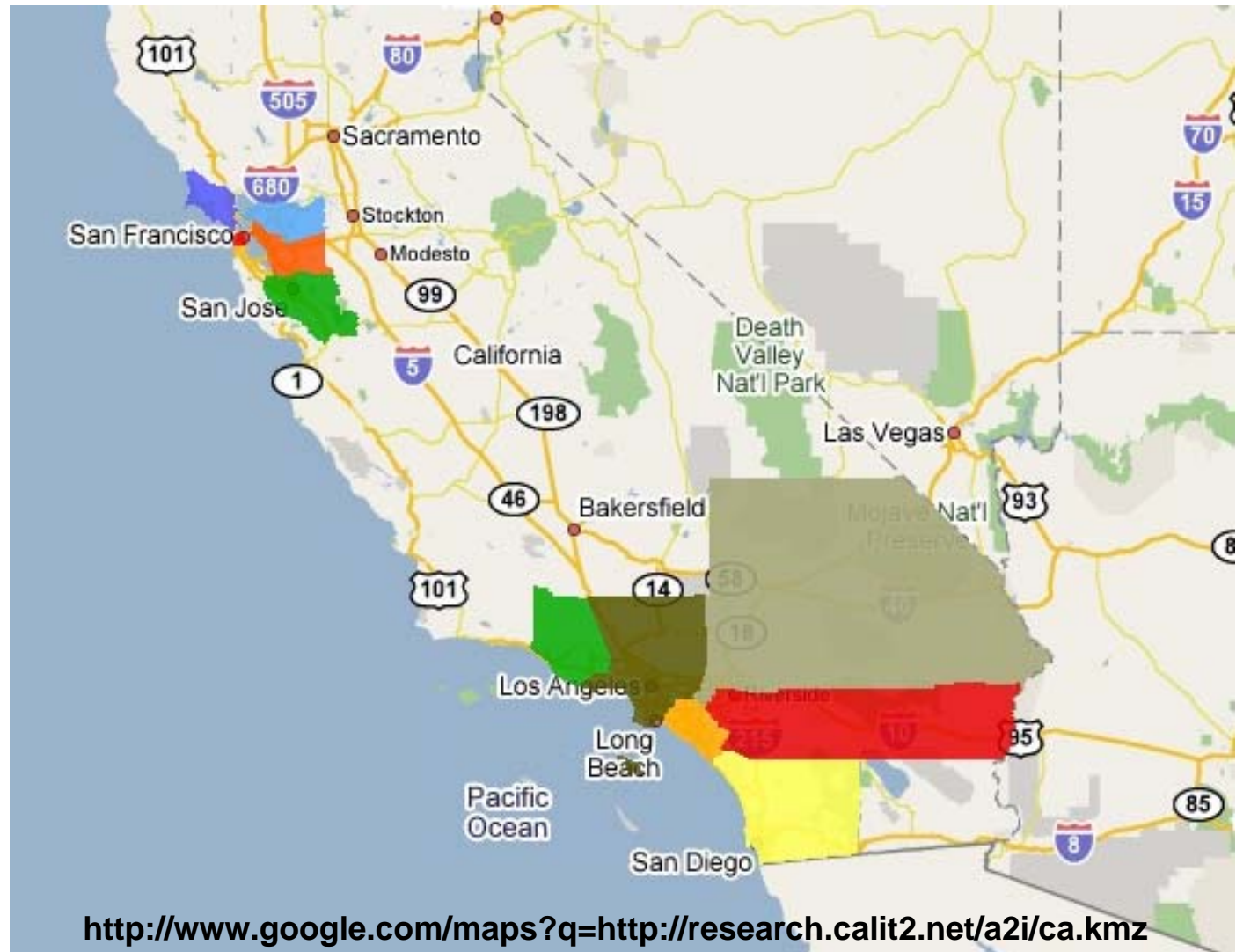**Principal Investigator, TransLight/StarLight**

The CineGrid™ Initiative

- **CineGrid is an initiative to provide media professionals access to global cyber-infrastructure capable of carrying ultra-high performance digital media using the photonic networks, middleware, transport protocols and collaboration tools originally developed for scientific research, visualization, and Grid computing.**

- **In the process, "learn by doing," train the next generation, and cultivate global inter-disciplinary communities to help advance the state of the art**

- **CineGrid is people, facilities, networks and a not-for-profit organization**

CineGrid Drivers

- **High-performance media is historically driven by three markets**
  - **1) Entertainment, media, art and culture**
  - **2) Science, medicine, education and research**
  - **3) Military, intelligence, security and police**

- **All three are in digital convergence and all need:**
  - **Fast networking with similar profiles**
  - **Access shared instruments, specialized computers and massive storage**
  - **Collaboration tools for distributed, remote teams**
  - **Robust security to protect intellectual property**
  - **Upgraded systems to allow higher quality, greater speed, more distributed applications**
 - **A next generation of trained professionals**

Economic Impact of Cinema in California

Major Employment from Movie Industry in California by County

In 2004, more than 236 new movies were produced in the State of California.

In 2005 movie production provided employment for over 245,000 Californians, with an associated payroll of more than $17 billion.

Typical big movies *each* spend more than $60 million on production, have a long-term $200 million economic impact, create more than 900 full-time jobs, and yield $11 million in state sales taxes and income taxes when fully made in California.

http://www.google.com/maps?q=http://research.calit2.net/a2i/ca.kmz

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CENIC Already Connects California Schools and Research Labs

- **Systems developed for CineGrid can be applied to scientific visualization and distance learning in many fields**

- **Useful information exchange between communities looking at "extreme" digital media problems from different perspectives**

- **CineGrid demonstrations will focus developers, driving a virtuous cycle of "learning by doing"**
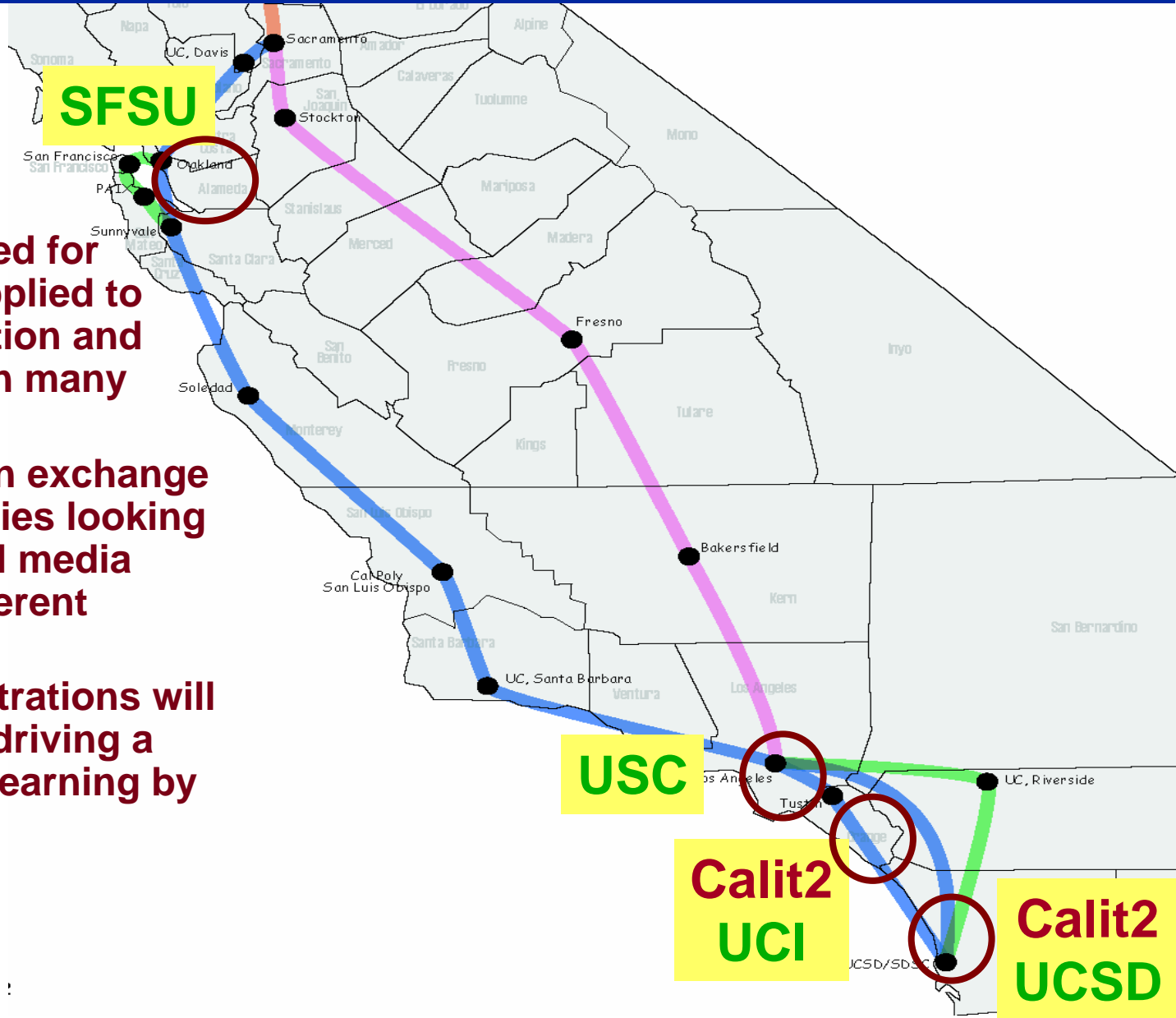
CENIC Connects to 10Gb Research and Education Networks Worldwide
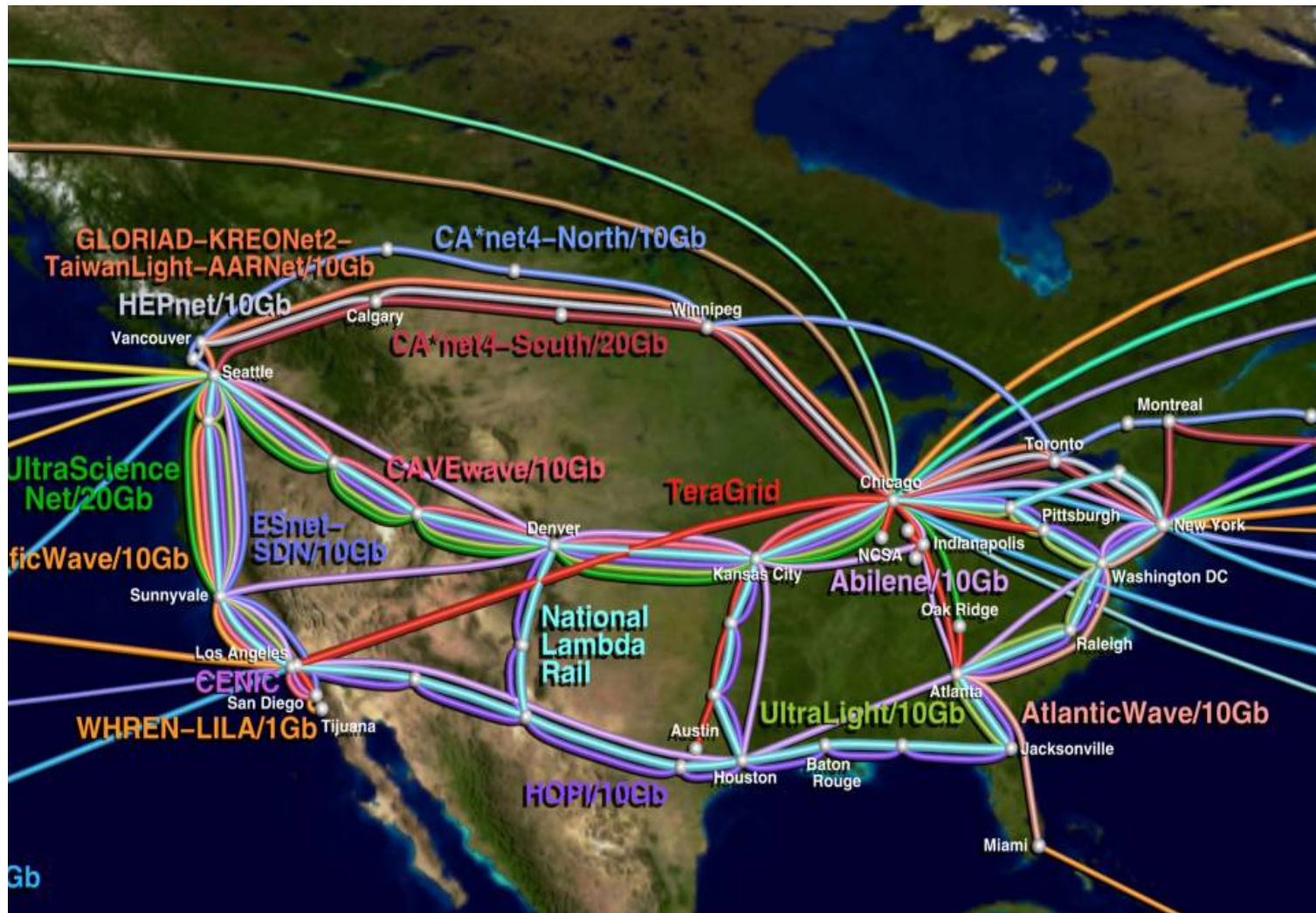
SMPTE 1981

Francis Ford Coppola with Dr. Takashi Fujio

"First Look" at Electronic Cinema

World's First 4K Digital Cinema System at NTT Labs 2000

First 4K Digital Cinema Demo for Hollywood Studios 2002

DCI Digital Cinema Specification 2005

"DIGITAL CINEMA INITIATIVES (DCI) ANNOUNCES FINAL OVERALL SYSTEM REQUIREMENTS AND SPECIFICATIONS FOR DIGITAL CINEMA

Agreement Gives Manufacturers of Digital Projectors and Theater Equipment One Universal Standard in Creating the Next Generation of Cinemas (Hollywood, CA - July 27, 2005)

Digital Cinema Initiatives, LLC (DCI) is a joint venture of Disney, Fox, Paramount, Sony Pictures Entertainment, Universal and Warner Bros. Studios. DCI's primary purpose is to establish and document voluntary specifications for an open architecture for digital cinema that ensures a uniform and high level of technical performance, reliability and quality control."

- **Image format: 2048x1080 (2K) and 4096x2160 (4K)**
- **Color: 12-bits/color, 4:4:4, SMPTE XYZ**
- **Frame rate: 24fps or 48fps for stereo**
- **Compression: JPEG 2000 up to maximum of 250 Mbps for distribution**
- **Encryption: AES 128 for Digital Cinema Package; SHA-2 (256bit) for Key**
- **Watermarking: invisible injection of time/screen ID in projected image**
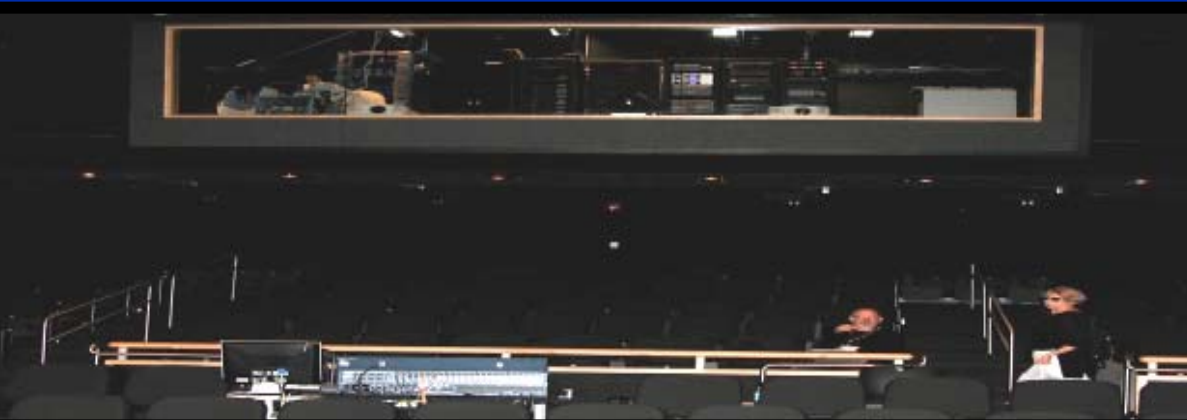
The CineGrid Node at UCSD/Calit2

200 Seats, 8.2 Sound, Sony SXRD 4K projector, SGI Prism w/21TB, 10GE connectivity, NTT JPEG 2000 codecs

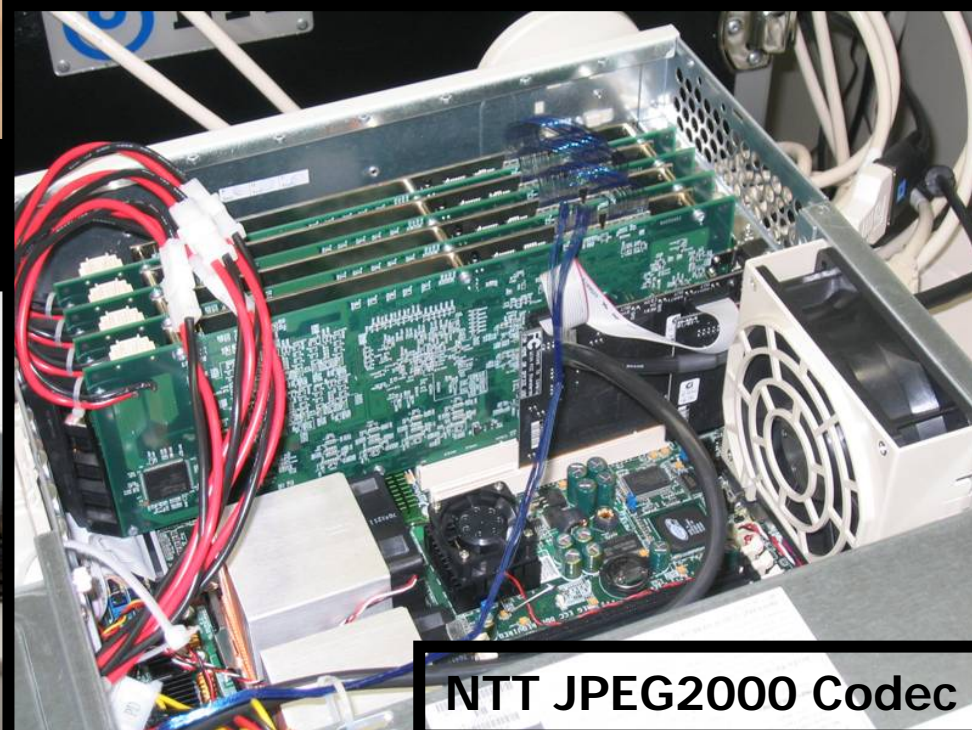# The CineGrid Node at Keio University, Tokyo Japan

Sony 4K Projectors

Olympus 4K Cameras

Imagica 4K Film Scanner

NTT JPEG2000 Codec

iGrid2005: Six Hours of 4K Streamed to Calit2 from Keio

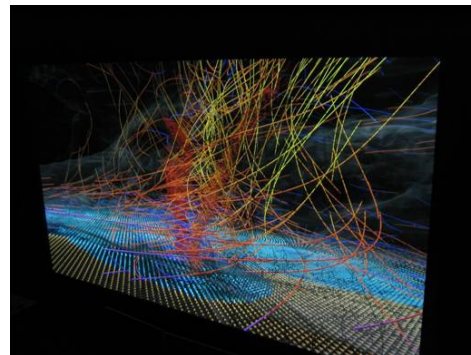4K Distance Learning (Live)

4K CG (Live)

4K Digital Cinema

4K Scientific Visualization

4K *Anime*

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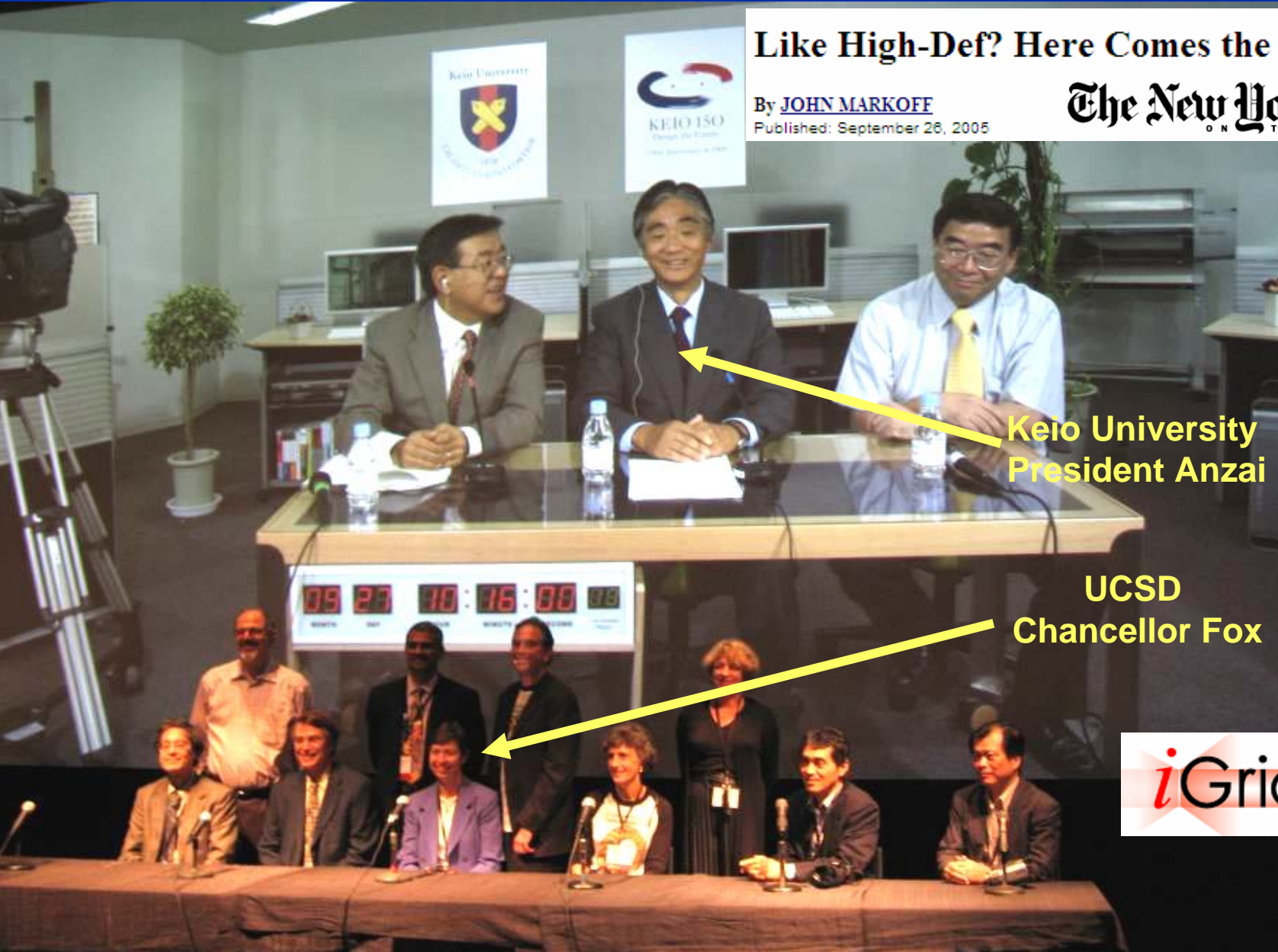
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Keio/Calit2 Collaboration: Trans-Pacific 4K Teleconference

Like High-Def? Here Comes the Next Level

By JOHN MARKOFF
Published: September 26, 2005

The New York Times
ON THE WEB

Keio University
President Anzai

UCSD
Chancellor Fox

Used
1Gbps
Dedicated

NTT
Sony
SGI
Olympus
Mitsubishi
Yamaha
Toppan

iGrid 2005

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"4K Pure Cinema" Joint Field Trial - Ongoing From October 2005
Warner Bros - Sony Pictures - Paramount
NTT Group - Toho Cinema - Warner Mycal
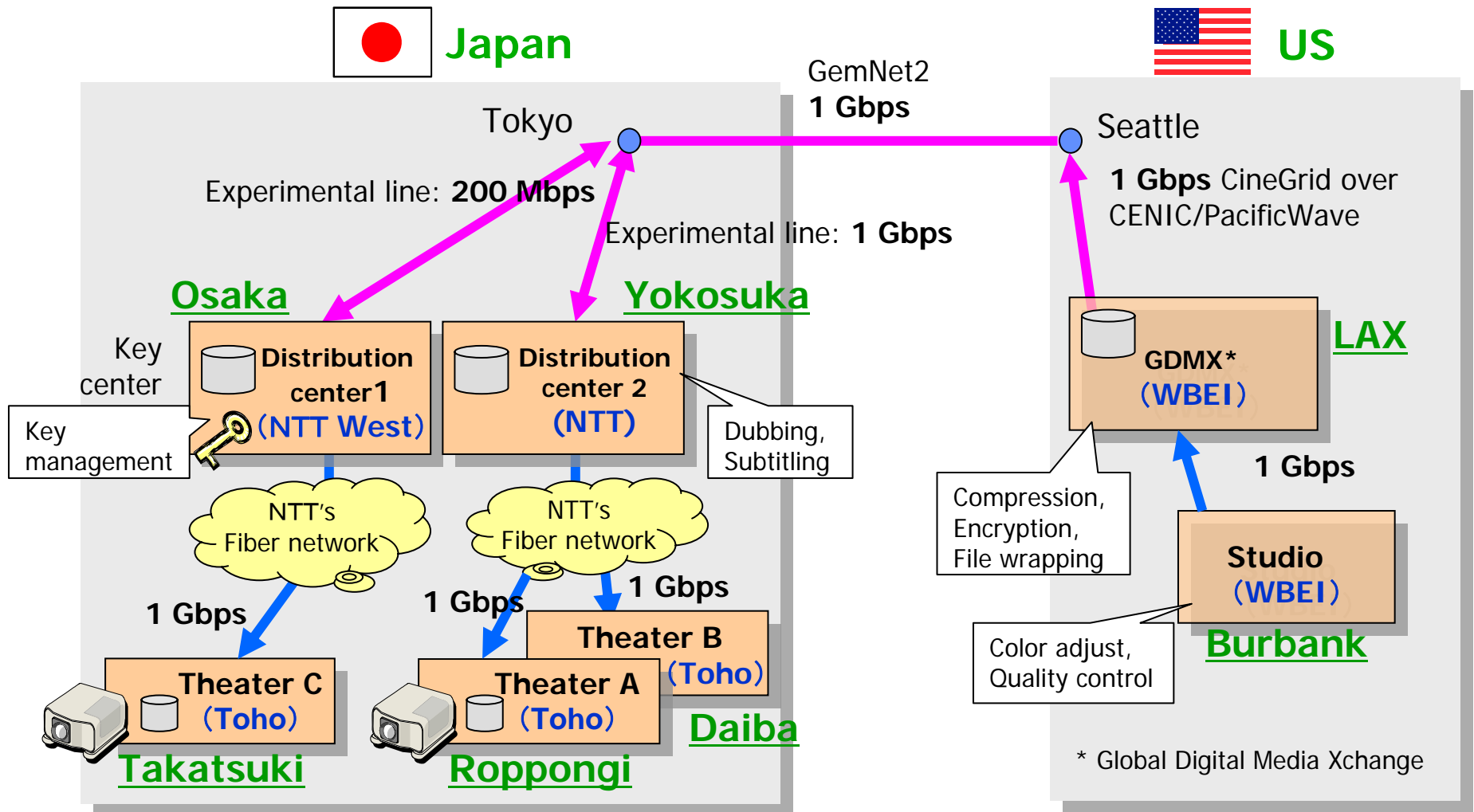
"4K Pure Cinema" Prototype In-Theater System

4K Projector

Theater Control Box (TCB)

Secure Media Box (SMB)
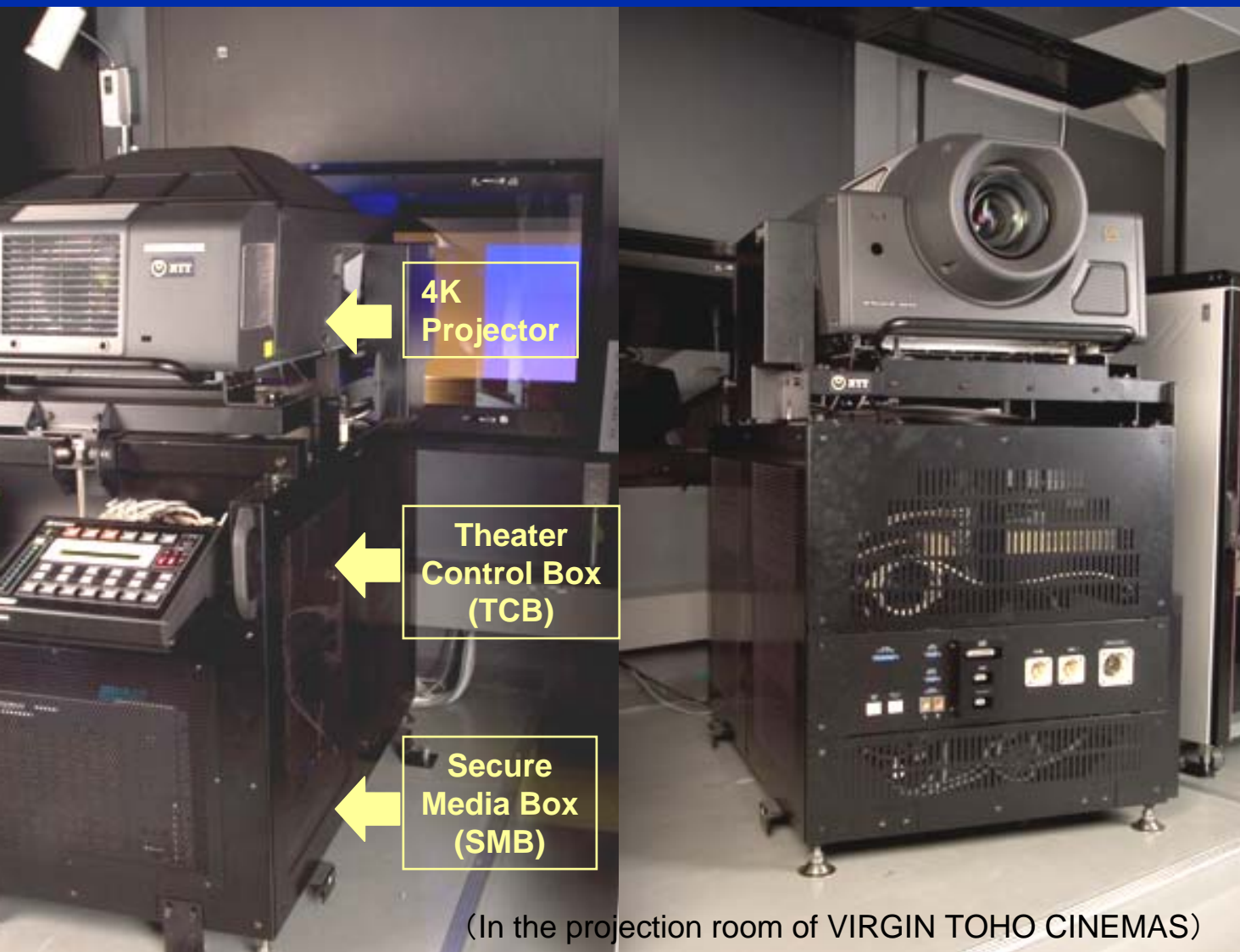
Corpse Bride
Harry Potter 4
V for Vendetta
DaVinci Code
Poseiden
Mission Impossible 3
+
Tokyo Film Festival
Batman Begins
Stealth

(In the projection room of VIRGIN TOHO CINEMAS）

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CineGrid Target Applications

- **Store-and-forward secure content delivery**
- **Streaming secure content transmission**
- **Pre-production collaborative design & planning**
- **Studio and remote production of sound and picture**
- **Digital dailies, interactive viewing & mark-up**
- **Distributed post production of audio/video**
- **Digital film scanning and restoration**
- **Digital media archiving**
- **Remote calibration and quality control of audio/video**
- **Education of next generation professionals**

These and other CineGrid applications will challenge the engineering of networked systems at every level

Initial CineGrid Experiment Tracks

- **CineGrid projects will be pre-commercial or non-commercial collaborations over networks. Definitions of 6 initial CineGrid research activities were developed at the 1st CineGrid workshop at Keio University/DMC in Tokyo in June 2006:**

  - **Distributed 4K digital film restoration**
  - **Distributed 4K digital movie production**
  - **Interactive 4K/HD-over-IP for remote collaboration**
  - **Networked audio for live performance and post-production**
  - **Distance learning at 4K/HD with Flexcast multicasting system**
  - **Distributed SD/HD video editing**
  - **Trusted systems using secure linux**

  These are just the first experiments… more to come!

CineGrid.org Starting in 2007

- **CineGrid will be established as a non-profit international membership organization administratively based in California, starting early 2007.**

- **To support members' research, CineGrid will organize network testbeds prepared to host a variety of experimental digital media projects designed to require very high bandwidth with appropriate security safeguards between a limited number of "trusted" users and systems around the globe.**

- **CineGrid will periodically organize inter-disciplinary workshops and demonstrations to share results and identify new avenues of research. Education and training of next-generation media professionals is our explicit goal.**
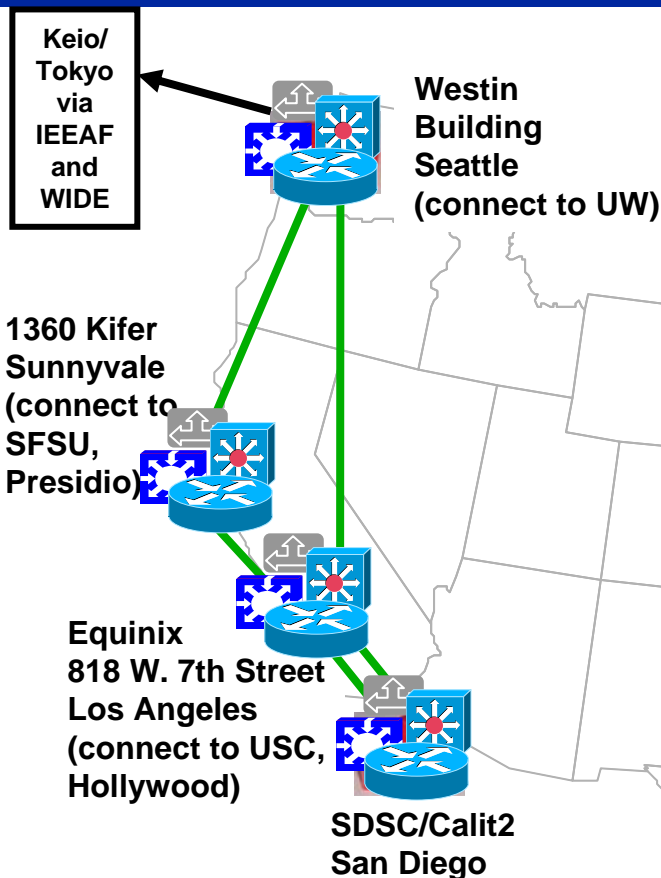
Next CineGrid Demonstration October 8th

- **October 8, 2006 during Audio Engineering Society (AES) Conference**

  - **LucasFilm's Letterman Digital Arts Center, Presidio, San Francisco**

  - **300 seat THX screening room**

  - **4K compressed (JPEG 2000) video streaming at 250-500 Mbps**

  - **24 Channels of uncompressed 20-bit/48KHz pre-mixed audio streaming at 25 Mbps**

  - **4K digital cinema signals will originate from Tokyo and Los Angeles and be synchronized with audio streaming from servers in San Diego, then viewed and mixed live in San Francisco.**

  - **The two-hour event will demonstrate networked delivery of 4K material to post-production professionals collaborating over great distances, and, of course, to audiences.**

  - **USC/CNTV, Los Angeles via VLAN over CENIC > Calit2**

  - **Keio/DMC, Tokyo via VLAN over WIDE/IEEAF/PacificWave/CENIC > Calit2**

  - **UCSD/Calit2, San Diego via VLAN over CENIC > SF CoLo > LucasFilm**

Next CineGrid Workshop in December

- **2nd CineGrid Workshop**
- **December 13 - 15, 2006**
- **UCSD/Calit2 in San Diego, California**

- **December 13 - Welcome Reception (evening)**
- **December 14 - Workshop for members with experiments underway or planned**
- **December 15 - Symposium for invited member-candidates, technology developers and supporting organizations**

- **For more information, please contact: tdefanti@ucsd.edu**

# Announcement: Cisco's NLR 10GE Waves and CENIC Enable Opening of West Coast (USA) CineGrid

Keio/ Tokyo via IEEAF and WIDE

Westin Building Seattle (connect to UW)

1360 Kifer Sunnyvale (connect to SFSU, Presidio)

Equinix 818 W. 7th Street Los Angeles (connect to USC, Hollywood)

SDSC/Calit2 San Diego

Cisco is building two 10 GigE "Cisco Waves" on NLR on the West Coast and switches for access points in San Diego, Los Angeles, Sunnyvale, & Seattle for CineGrid

CENIC is making available persistent 1 GigE access ports in San Diego, Los Angeles, Sunnyvale, & San Francisco for CineGrid

Via GLIF, CineGrid extends to Japan via Seattle & Chicago; to Canada via Seattle & Chicago; to Europe via Chicago & Amsterdam. Further extension likely to China, Korea, Singapore, India, New Zealand, Australia, others.
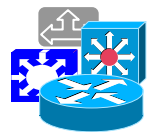
Cisco NLR CineGrid Node
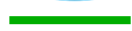
10GE Cisco NLR CineGrid Waves

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Source: John Jamison

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Conclusion: A Global Infrastructure for Digital Cinema Will Expand the User Base for GLIF

- We are just in the beginning of the same sort of DIGITAL transition for cinema that transformed television and music in the 1990s.

- Digital media professionals, especially those making digital cinema, increasingly work as distributed teams of collaborators. They require high speed networks to accomplish their creative work, yet few have access to the cyber-infrastructure needed to test new distributed workflows.

- CineGrid aims to connect the most advanced digital facilities in the world with the highest-performance digital production and presentation equipment to the best computing and networking available.

- CineGrid has multiple experimental projects underway and is organizing itself to host more collaborations over more GLIF networks.

- Countries that adopt these innovations from university prototyping into their mainstream media industry *faster* than the rest of the world will benefit economically.

Thank You Very Much!

- **Our planning, research, and education efforts are made possible, in major part, by funding from:**
  - US National Science Foundation (NSF) awards ANI-0225642, EIA-0115809, and SCI-0441094
  - State of Illinois I-WIRE Program, and major UIC cost sharing
  - State of California, UCSD Calit2
  - Many corporate friends and partners
- **Argonne National Laboratory and Northwestern University for StarLight and I-WIRE networking and management**
- **National Lambda Rail, Pacific Wave, CENIC and Cisco Systems**
- **NTT Network Innovations Lab**
- **Pacific Interface, Inc.**

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First USA Demo of 4K Digital Cinema System at Siggraph 2001

International Real-Time Streaming of 4K Digital Cinema

System diagrams

Image Format
3840x2160 YPbPr 422
24 or 29.97 frame/sec

Audio Format
2ch or 5.1ch .WAV
24 bit/48 KHz

KEIO/DMC

Olympus 4k Cameras

SGI PRISM + RM-660

TOPPAN CLUSTER

HD-SDI Switch

Mitsubishi Electric Server

NTT J2K CODEC

NTT J2K Server

GigE

NTT Flexcast

GigE

Gigabit IP Network

Sony 30" Plasma HDTV

NTT Electronics MPEG2 CODEC

Gigabit IP Network

UCSD/Calit2

Gigabit IP Network

NTT Flexcast

GigE

NTT J2K CODEC

GigE

NTT J2K CODEC

SHD LCD

Sony SXRD 4K Projector

NTT Electronics MPEG2 CODEC

Sony HDTV Camera

iGrid 2005

CineGrid: A Scalable Approach

8K x 60   8K (far future)

$4K^2$ x 24/30   Stereo 4K (future)

4K x 24
$2K^2$ x 24
2K x 24/48   Digital Cinema

HD^2 x 24/30   Stereo HD

HD x 24/30   Pro HD

HDV x 24/30   Industrial HD
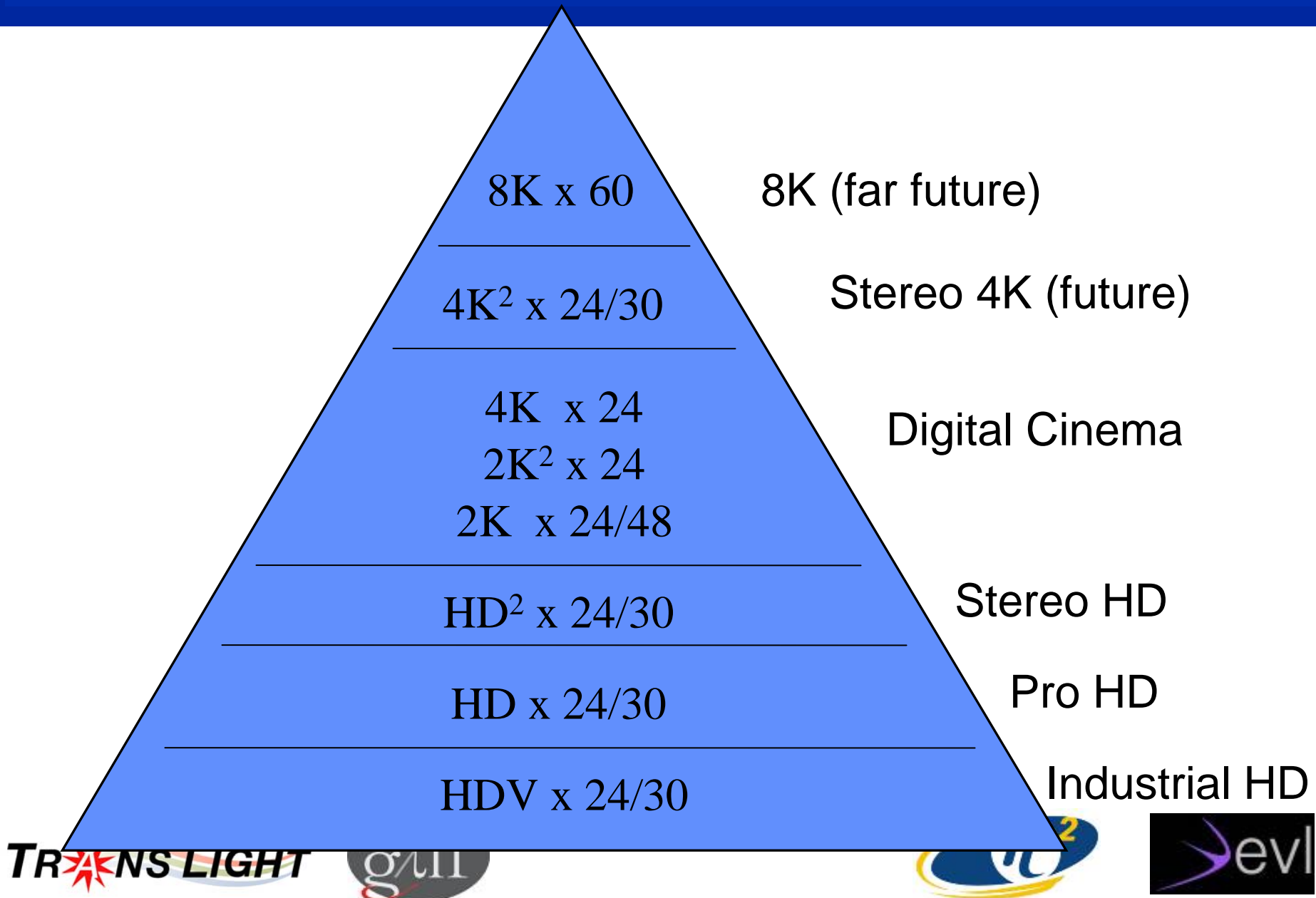
Many HD-over-IP Experiments at iGrid2005

- **Global N-Way Interactive Conferencing using the iHD1500 system from the ResearchChannel, University of Washington. This experiment features uncompressed HDTV communication among multiple sites. Involved participants are Pacific Northwest GigaPoP, University of Wisconsin-Madison, USA; AARNet, Australian Partnership for Advanced Computing, Australia; SURFnet, NL; and WIDE, Japan.**

- **HDTV Multipoint Conferencing from Masaryk University, CESNET, Czech Republic to UCSD, involving uncompressed HDTV multicast over optical networks. <See FGCS, Vol. 22/Issue 8(2006)>**

- **Interactive 3D HDTV between KISTI, Kyungpook National University, Gwangju Institute of Science and Technology, Korea Advanced Institute of Science and Technology, Korea, and UCSD via CANARIE of Canada. It involved uncompressed and compressed mono and stereo HDTV, as well as distributed data grid tools. <See FGCS, Vol. 22/Issue 8(2006)>**

- **20,000 Terabits Beneath the Sea. The University of Washington, UCSD Scripps Institution of Oceanography, Calit2, ResearchChannel, and Pacific Northwest GigaPoP all collaborated to show the first real-time HDTV from deep-sea, high-temperature venting systems associated with active underwater volcanoes.**

More HD-over-IP at iGrid2005

- **Real-Time Observational Data Streaming** − NCHC, National Museum of Marine Biology & Aquarium, Academia Sinica, Taiwan; SDSC, Calit2, UCSD, USA; Nara Institute of Science and Technology, Osaka University, Japan; CANARIE, Canada; Edinburgh University, UK. **This experiment uses mono and stereo underwater HDTV cameras as a source to stream images from Taiwan's EcoGrid**

- **Scalable Adaptive Graphics Environment (SAGE)** − UIC, USGS, Univ. of Chicago, USA; SARA Computing and Networking Services, NL; KISTI, Korea. **Displays multiple incoming streams of computer graphics and live HDTV on the 100Megapixel LambdaVision; CytoViz displays network statistics of streams <See FGCS, Vol. 22/Issue 8(2006), p. 964>**

- **Unreliable Stream** − SARA Computing and Networking Services, NL. **Transfers images using UDP, a lossy network protocol <See FGCS, Vol. 22/Issue 8(2006), p. 972>**

- **NCSA Streaming Stereo** − NCSA, UIC, USA. **A bulk movie playback package (bplay) integrated into SAGE <See FGCS, Vol. 22/Issue 8(2006), p. 967>**